

Influence of Integrated Nutrient Management on Yield of Coconut (*Cocos Nucifera*) on Sandy Soils

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ABSTRACT

The study mainly to find out the effect of activated biomass on the yield of 10 years of *Ceylon* tall coconut plants at bris soil to develop a fertilizer mixture that supports plant productivity. The activated biomass was derived from coconut fronds and empty fruit bunch which were air-dried and carbonized in a stainless steel fabricated kiln at a temperature between 250°C-350°C for 4 h to develop the activated biomass. Seven treatments including control were selected. Measurements of yield parameters viz., fruit weight, nut weight, husk weight, water volume, fruit perimeter, fruit length, flesh thickness and the number of nuts increased were conducted every 2 months. There are significant differences at ($P < 0.05$) were observed in some yield parameters, percent of nut increased, flesh thickness and fruits parameter were highest at T3. The treatment of T6 shows the highest records of fruits length, water volume, the weight of fruits, and husks weight. T7 recorded the highest reading of stem diameter. Further field evaluations are needed to determine the relationship of the level of activated biomass with the different level amount of NPK supply in inducing the nutrient availability and soil microbial.

Keywords: Coconuts, Nutrient management, Empty fruit bunch, Coconut fronds, Activated biomass, Coconut yields, Sandy soil.

1. Introduction

Coconut is a versatile tree and is the most popular home garden crop in the world and very beneficial for health because of its high nutrient status (Parwaiz et.al. 2014). Coconut is grown under highly heterogeneous soil conditions ranging from coastal sand to clay, from poorly drained uplands to hill slopes and strongly acidic to highly calcareous soils (Khan *et al.*, 1978). Nutrient management in coconut is a continuous battle against soil limiting factors and it assumes significance because coconut requires a continuous supply of nutrients throughout the year for sustained productivity (Khan, 1993). For better growth and productivity of coconut palms balanced and integrated nutrient management is essential.

Integrated Nutrient Management includes the intelligent use of organic, inorganic, and biological resources to sustain optimum yields, improve or maintain soil chemical and physical properties (Tandon, 1990). Plantation crops have sufficient potential to benefit from natural farming and sustain their yield with low external input as they produce considerable quantities of biomass (Nampoothiri, 2001). Being a perennial crop, the coconut palm produces huge quantities of organic wastes throughout the year.

The availability of organic recyclable biomass from a hectare of well-managed coconut garden has been estimated to be about 14–16 tons annually in the form of leaves, spathe, bunch waste, and husk. Sustainable agricultural production incorporates the idea that natural resources should be used to generate increased output and incomes, without depleting the natural resources (Parwaiz et.al. 2014).

The use of these waste materials as domestic fuel and thatching material is now limited due to the change in the lifestyle of the rural population. The waste biomass from coconut palm differs significantly in the chemical

composition (Thomas et al., 1998). The application of biomass organic integrated with Nitrogen, Phosphorus and Potassium (NPK) will enhance for best growth performance of coconut. The conjunctive use of organic and inorganic sources improves soil health and helps in maximizing production as it involves the utilization of local sources and, hence, turned to be a rational, realistic and economically viable way of supply of nutrients (Parwaiz et.al. 2014). The application of biomass organic from coconut waste will increase the nutrient contents for plants uptake (Khairol. I and Mohammad. A. H., 2019). The research work was initiated to study the impact of activated biomass from palm wastes on the yield of coconut planted on marginal bris soil.

2. Methodology

2.1. Experimental site

The experiment was carried out for two years in a plot of 10 years old coconut palm of Ceylon tall cultivar at Malaysian Agriculture Research And Development Institute (MARDI) Station in Cherating, Pahang, Malaysia. The daily temperature during the experiment was in the range of 30–40°C. The research station received an annual average rainfall of 600 mm on 30 rainy days distributed from September to November. The soil was Beach ridges interspersed with swale (*BRIS*) with low pH and low availability of Nitrogen (N), Phosphorus (P) & Potassium (K).

2.2. Planting materials

Ceylon tall of coconuts at the age of 10 years were used in a fully randomized design horizontally on raised plots at a spacing of 9.0 m between seedlings and 9.0 m between rows triangularly.

2.3. Activated biomass development

The activated biomass was derived from coconut fronds (CF) and empty fruit bunch (EFB). Raw of CF was collected from MARDI Bagan Datuk Field and EFB biomass was collected from Sg Sumun Oil Palm Mill, Sime Darby Bhd, located in Bagan Datuk, Perak, Malaysia. The Biomass samples were air-dried for one week to eliminate excessive moisture. The biomass was then chopped in the size of ≤ 50 mm. The biomass sample was carbonized in the stainless steel fabricated kiln at a temperature between 250°C - 350°C for 4 h to develop the activated biomass. The activated biomass was shredded to the size ≤ 5 mm before apply to the experimental plots.

2.4. Treatments

Seven rates of activated biomass were applied in the experiment and it was combined with 4.50 kg/palms of Nitrogen, Phosphorus and Potassium (NPK) 12:12:17:2 compound for each plant. The activated biomass was applied at the basin of palm within 2 meters from the stem of coconuts. The NPK was applied above the activation that was applied before. The treatments are as follows: T1- Control (NPK only), T2- CF 3.0kg/plant + 4.5 kg/plant of NPK, T3- CF 6.0kg/plant + 4.5 kg/plant of NPK, T4- CF 9.0kg/plant + 4.5 kg/plant of NPK, T5- EFB 3.0kg/plant + 4.5 kg/plant of NPK, T6- EFB 6.0kg/plant + 4.5 kg/plant of NPK, T7- EFB 9.0kg/plant + 4.5 kg/plant of NPK.

2.5. Data of yield characters

The number of fruits and copra weight per palm were recorded each year from the middle of 2019 to the middle of 2021. The yield parameters viz., fruit weight (gm), nut weight (gm), and husk weight (gm) were measured using a

digital scale. Flesh thickness (mm), fruit length (cm) and fruit perimeter (cm) were measured using a calliper and measuring tape. Water volume (ml) and Brix were measured using a measuring cylinder and portable Brix meter while yield increased (%) recorded every two months year wise from 2019 - 2021. The results of the study were analyzed and discussed in the paper.

2.6. Experimental design and data analysis

The experimental design was a Complete Randomized Design. Analysis of variance tests was carried out to detect significant differences between the parameters collected with 2 replication. Means of the measured variables were compared by using the appropriate ANOVA procedure (SAS Institute 1989) and the Duncan test ($P < 0.05$).

3. Results and Discussions

3.1. ANOVA analysis of parameters

The ANOVA analysis suggested that parameters collected (fruit weight, husk weight, water volume, fruit length, and yield increased) were significantly affected by treatments (Table 1). On the other hand, fruits perimeter and nut weight does not significantly affect the treatments.

3.2. Effect of activated biomass on yield of coconut increasing

Yield data of the increasing nuts at parameter number of fruits per plant/year was mentioned in table 2. A significant difference at ($P < 0.05$) in the yield of nuts/plants was observed between the activated biomass treatments. Treatment T3 shows the highest percent of nut increment with 44.8%, while T1 shows the lowest nut increment with 9.4%. It is a significant difference in yield increases at ($P < 0.05$) due to effected by activated biomass applied. This in turn helped the palms in increasing the nutrient content which eventually influenced the reproductive behaviour of the coconut palms and ultimately reflected in the nut yield (Shinde et al. 2021). Burying a thousand coconut husks per palm plus coconut leaves in the trenches between rows raised yield by 44.6% over the control (Balasubramanian et al. 1985).

Table 1. Analysis of *mean square* ANOVA on effect of activated biomass to the yield components of coconuts

Source of variance	Parameters							
	Fruit weight (gm)	Nut weight (gm)	Husk weight (gm)	Water volume (ml)	Fruit perimeter (cm)	Fruit length (cm)	Yield Increased (%)	Flesh Thickness (mm)
Treatment	149506.67*	7028.84	117641.63*	2610.15*	7.72	2.31*	321.77 *	2.91*
Rep	128918.42	17955.13	50649.91	942.34	12.50	0.07	369.26	0.36
Grand mean	1462.39	705.45	756.94	169.06	54.39	20.70	26.78	12.75
Coefficient of variation (%)	9.75	12.64	13.99	12.00	2.90	2.79	13.90	10.89

Note: mean along with * shows the significant difference at $p \leq 0.05$

: mean along with ** shows the significant difference at $p \leq 0.01$

Table 2. Yield performance on number of fruits/plant/year at different activated biomass rate

Treatments	No of fruits/plant/year		
	Pre-treatment	Post-treatment	Percent increase %
T1	35	38	9.4 d
T2	27	33	24.6 bc
T3	20	29	44.8 a
T4	24	34	40.6 ab
T5	29	33	15.1 c
T6	16	19	27.8 bc
T7	28	36	25.3 bc
Grand mean	25	32	26.78
C.V. (%)	-	-	13.90

Mean value with the same letter for each treatment are significantly different at $P < 0.05$

3.3. Effect of activated biomass on physical characters of nuts

3.3.1. Fruits and Husks weight

A brief description of fruits weight parameters were given in figure 1. It shows a significant difference in the weight of the fruit at ($P < 0.05$) that was observed between the activated biomass treatments. The treatment of T6 shows the highest weight of fruits significantly compare to other treatments, while T1 shows the lowest weight of fruits affected by activated biomass applied. Yield parameters of husk weight were mentioned in figure 2.

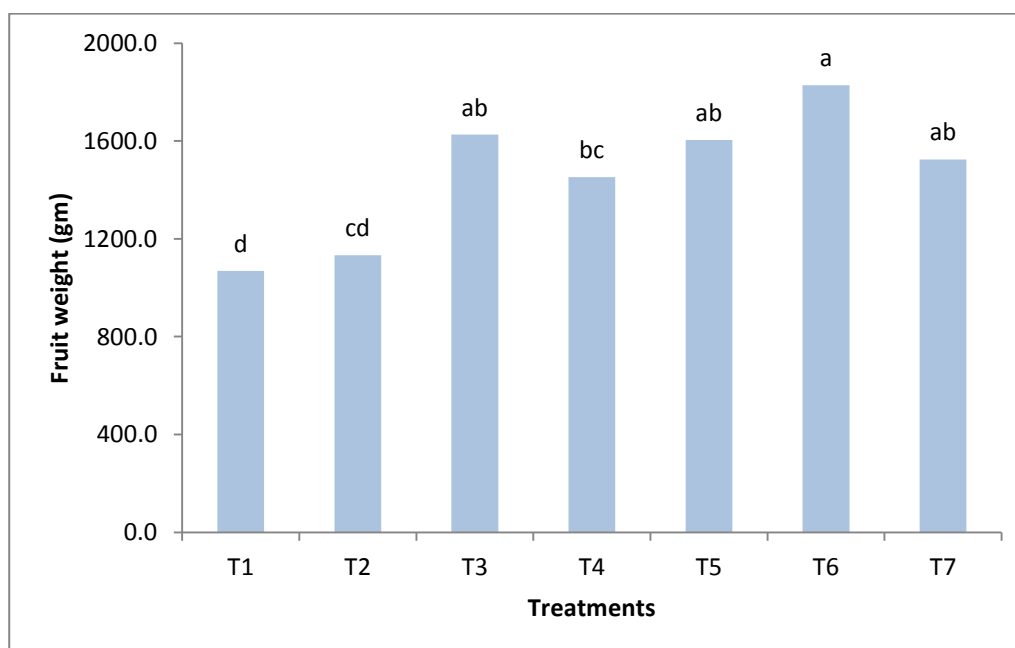


Fig.1. Effect of activated biomass rate to the relationship between treatment and fruits weight. Bar with the same letter for each treatment are significantly different at $P < 0.05$

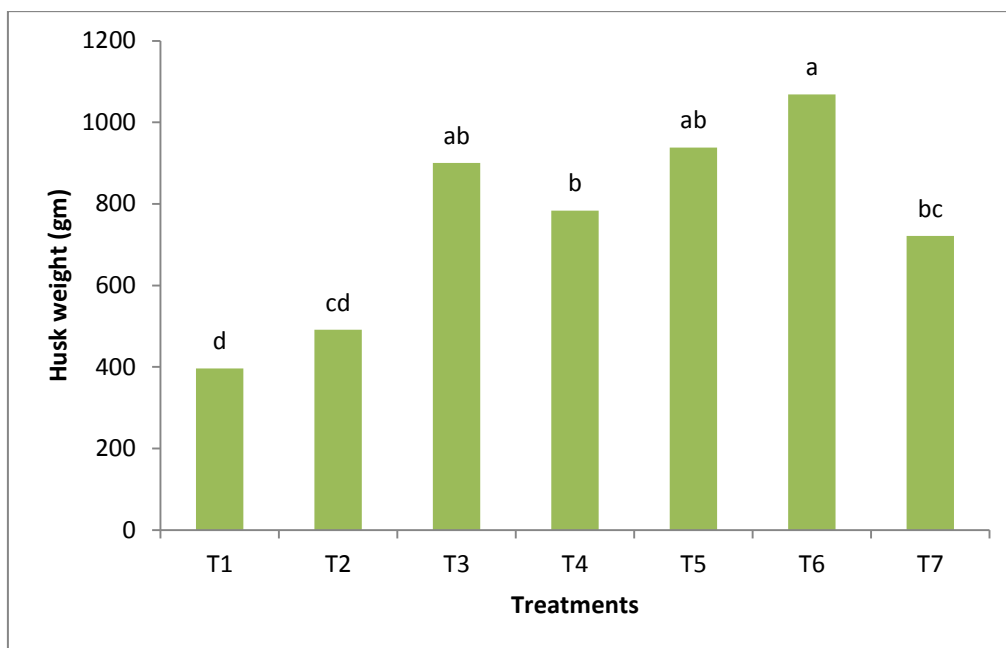


Fig.2. Effect of activated biomass rate to the relationship between treatment and husk weight. Bar with the same letter for each treatment are significantly different at $P < 0.05$

There is a significant difference in the husk weight observed at ($P < 0.05$) affected by different rates and types of activated biomass applied. The treatment of T6 shows the highest weight of husk, followed by T5 and T3, while T1 shows the lowest husk weight parameters compared to other treatments. These results indicate that different amendments affect yield characters differently. Similar results were obtained in the case of other plants that it is suggested that amendment of BRIS soil increased BRIS soil health therefore yield of vegetable plants increased (Khandaker, et. al 2014). Integrated nutrient management affects its growth and yield characteristics to a great extent (Parwaiz et.al. 2014). Therefore the yield increased in BRIS soil under amendment-BRIS soil conditions than only BRIS soil conditions (Khandaker, et. al 2014).

3.3.2. Nut weight and fruits perimeters

Nut weight was not significantly affected by treatments. Nevertheless, T7 recorded the highest reading of nut weight while T2 was the lowest (Table 3).

Table 3. Nut weight and fruit perimeter effect at different activated biomass rate

Treatments	Parameter	
	Nut weight (gm)	Fruit perimeter (cm)
T1	672.4 a	52.4 a
T2	641.6 a	52.1 a
T3	725.8 a	56.9 a
T4	668.7 a	54.6 a
T5	666.1 a	53.4 a

T6	760.1 a	56.9 a
T7	803.5 a	54.5 a
Grand mean	705.5	54.4
C.V. (%)	12.64	2.9

Mean value with the same letter for each treatment are not significantly different at $P < 0.05$

Fruits perimeter also shows a similar pattern whereby T3 and T6 recorded the highest reading while T2 was the lowest. However, no significant impact was established. An increase in yield under these treatments might be owing to better availability of required nutrients which resulted in improvement in yield (Maheswarappa. et al 2014) and (Maheswarappa. et al 2011). When the nut yields after imposition of treatments are compared with the figures before the experimentation, there was a considerable increase in yield as affected by integrated nutrient management treatments (Chellappa, 2008).

3.3.3. Water volume

Yield parameters of water volume were described in figure 3. There is a significant difference in the water volume observed at ($P < 0.05$) affected by activated biomass applied. Treatment T6 shows the highest reading of water volume while T3 and T7 were at par. T1 shows the lowest significant reading. The organoleptic evaluation of tender nut water revealed that the treatments which received more organic fertilizers recorded very good taste (Chellappa, 2008). High-temperature biochar's' porous structures can accommodate appropriate soil-microorganism activities, increase water sorption, and increase soil density. Furthermore, the biochar's' high alkalinity can help to neutralise acidic soil, increasing soil fertility and plant development (Dhar et al. 2020).

3.3.4. Fruit length

A significant difference in the fruit length at ($P < 0.05$) was observed between the treatment (Figure 4).

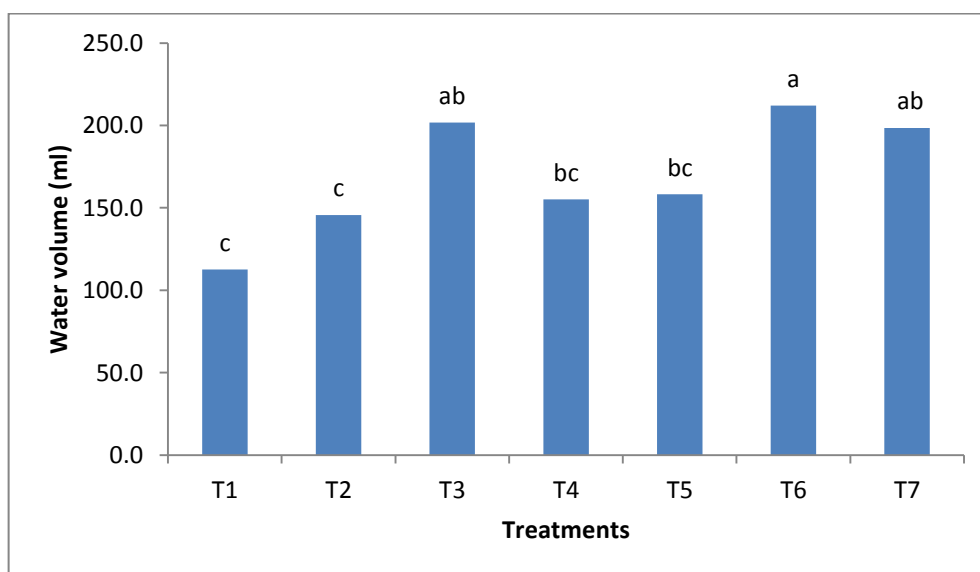


Fig.3. Effect of activated biomass rate to the relationship between treatment and water volume. Bar with the same letter for each treatment are significantly different at $P < 0.05$

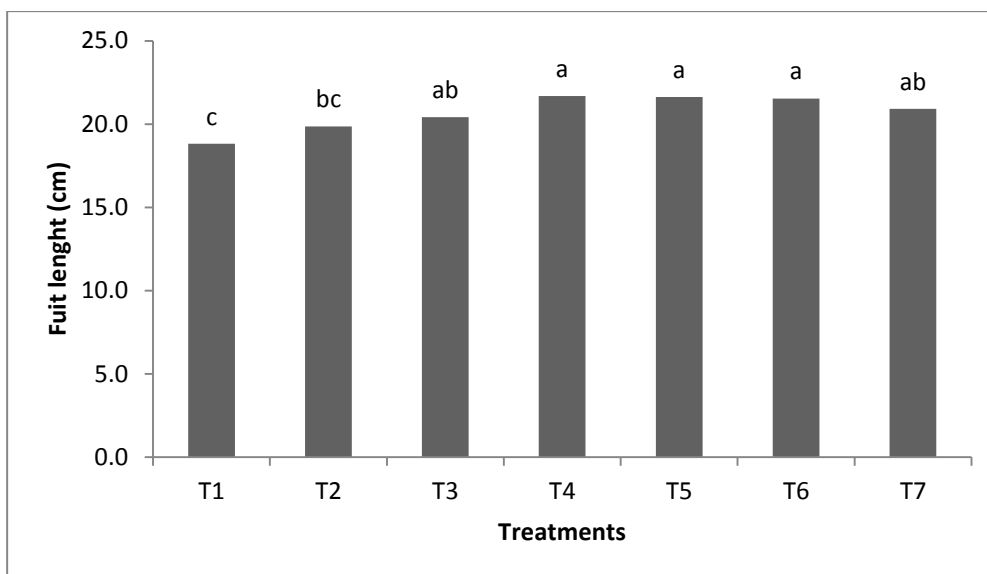


Fig.4. Effect of activated biomass rate to the relationship between treatment and fruit length. Bar with the same letter for each treatment are significantly different at $P < 0.05$

The palm at treatment T4, T5, and T6 contribute to the highest reading of fruits length. Unfortunately, T1 was observed as the lowest significant reading. It can be discussed that the activated biomass applied were contributed the most yield and differences among treatments to the parameter different of fruit length. This biomass may be recycled back into the system, improving soil fertility and crop yield in a sustainable manner. Productivity is also affected by different nutrient management practices. The combination of organic and inorganic sources, bio fertilizers, and specific plant growth regulators boosted plant growth and hence biomass output (Sainath et al. 2021).

3.3.5. *Flesh thickness*

The flesh thickness of coconut was described in figure 5.

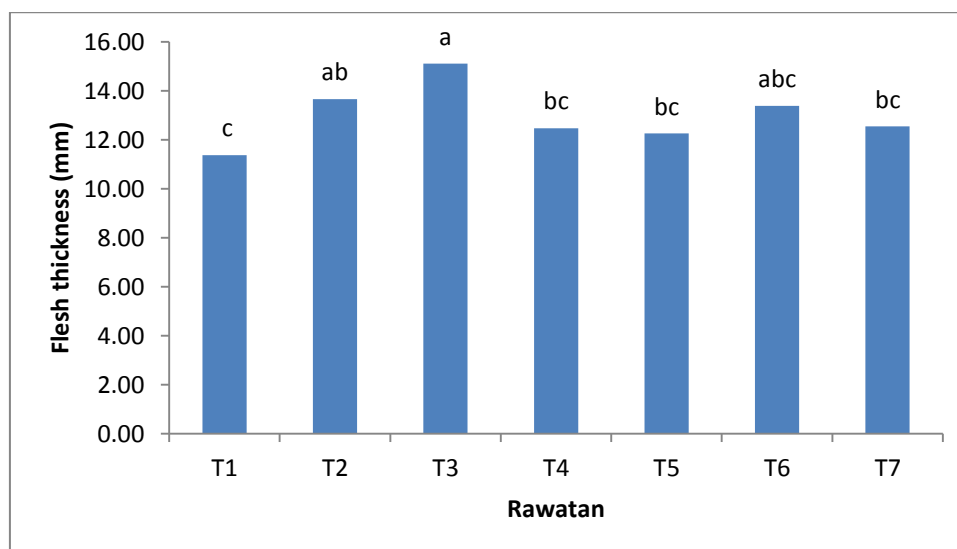


Fig.5. Effect of activated biomass rate to the relationship between treatment and flesh thickness. Bar with the same letter for each treatment are significantly different at $P < 0.05$

There is a significant difference in the thickness of coconut fleshes at ($P < 0.05$) affected by activated biomass applied. Treatment T3 shows the highest significant reading of fleshes thickness while T1 shows the lowest significantly. However, T2 and T6 revealed equivalence among the highest readings. Bavappa (1986) noted additional benefits of organic materials (coir dust, coconut shredding, forest leaves, and cattle manure) plus the recommended dose of NPK improved the initial growth and reduced the mortality of coconut seedlings in coastal sandy soil. To minimize damaging effects of drought through the association of organic fertilization which using mulching – covering the soil around the palm by a layer, e.g., coconut fronds, husks, lopping of *Gliricidia*, *ipil-ipil* and *sun-hemp* (Abeywickrama et al. 1983).

3.4. Correlation analysis between parameters collected

The findings show in table 4 the strength of the positive relationship between parameters. Fruit weight had a significant positive correlation with all the parameters evaluated in this study (Table 4). However, only nut weight, husk weight, water volume, and fruit length were significantly affected by the treatment shared a significant positive correlation with fruit weight. Therefore, increasing the readings of these parameters has the potential to increase the fruit weights. The recycling of biomass by vermicomposting and field application will reduce the chemical fertilizer requirement of coconut and the cost of cultivation (Shinde et al. 2021). The promise of pyrolysis as a novel method for the rapid recycling of highly resistant coconut palm biomass leftovers to biochar as a locally available source of soil amendment to promote regenerative agriculture in humid tropics (Gopal et al. 2020).

Table 4. Analysis of mean correlation on the yield components of coconuts

	Nut weight (gm)	Husk weight (gm)	Water volume (ml)	Fruit perimeter (cm)	Fruit length (cm)	Fruit weight (gm)	Flesh Thickness (mm)
Nut weight (gm)	1	0.36	0.73	0.69	0.23	0.61	0.23
		Ns	*	*	ns	**	ns
Husk weight (gm)		1	0.73	0.77	0.78	0.96	0.25
			*	**	**	**	ns
Water volume (ml)			1	0.80	0.55	0.84	0.54
				**	*	**	*
Fruit perimeter (cm)				1	0.45	0.86	0.38
					ns	**	ns
Fruit length (cm)					1	0.73	0.15
						*	ns
Fruit weight (gm)						1	0.28
							ns
Flesh Thickness (mm)							1

Note: mean along with * shows the significant difference at $p \leq 0.05$,

: mean along with ** shows the significant difference at $p \leq 0.01$

4. Conclusion & Future Recommendations

According to the findings of the preceding study, the use of activated biomass in conjunction with inorganic fertilizer of NPK combination was found to be beneficial in increasing coconut yield. Considering the increased mean nut yield as well as yield character components parameters such as nut weight, husk weight, water volume, fruit perimeter, fruit length, and fruit weight, it can be concluded that the use of INM treatments such as T3 (T3- CF 6.0kg/plant + 4.5 kg/plant of NPK) and T6 (T3- EFB 6.0kg/plant + 4.5 kg/plant of NPK) were found promising and produced higher readings. It is the system that envisions judicious combinations of organic wastes, bio-fertilizers, and inorganic fertilizers to sustain soil productivity. As a result, the discovery could aid in the recommendation of coconut farmers under coastal ecosystems where the expenditure on chemical fertilizers can be saved. It can be concluded that the application of organic biomass integrated with NPK will enhance for best yield performance of coconut. Amended soil boosted plant physiological indicators, indicating increased BRIS soil health and improving not just soil condition but also plant variables. The usage of organic biomass obtained from coconut trash will boost nutritional content for plant uptake. If applied, the approach may cover the nutritional demands of seedlings at the field stage, considerably cutting the cost of field maintenance production and creating well-healthy plants for planting. Incorporating organic compost into INM methods can aid not only incompletely or partially substituting inorganic fertilisers, but also in helping farmers to recycle various agricultural waste into a more sustainable, cost-effective, and environmentally friendly.

The study also has limitations because information on the activated carbon biomass study for field stages of coconuts in Malaysia is limited. Further field studies are required to determine the relationship between the level of organic biomass and the total amount of NPK supply in inducing the growth and yield of coconut planted in other marginal soil i.e. peat. tin-tailing and acid sulphate soil.

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Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

References

- 1) Abeywickrama, B., D.V. Liyanage And P.R. Wijewardane. 1983. Measures To Minimize Drought Damage In Coconut Plantation. Ministry Of Coconut Industries, Colombo, Sri Lanka.
- 2) Ahmad R.K., Sulaiman S.A., Inayat M., Umar H.A. (2020). Effects Of Process Conditions On Calorific Value And Yield Of Charcoal Produced From Pyrolysis Of Coconut Shells. In: Emamian S.S., Awang M., Yusof F. (eds) *Advances in Manufacturing Engineering. Lecture Notes in Mechanical Engineering*. Springer, Singapore. https://doi.org/10.1007/978-981-15-5753-8_24.
- 3) Balasubramanian, R., T. Ramanathan And H. Vijayaraghavan. 1985. Certain Aspects Of Moisture Conservation In Coconut Gardens. *Indian Coconut J.* 16(2):13-15.
- 4) Bavappa, K.V.A. 1986. Research At Cpcri. Kerala, India.
- 5) Che Lah, Mohd & Nordin, Mohd Nozulaidi & Isa, Musliania & Yusop, Mohd & Jahan, Md. (2011). Composting increases BRIS soil health and sustains rice production. *ScienceAsia*. 37. 291-295.
- 6) Chellappa, Jayabose. (2008). Impact of integrated nutrient management on nut yield and quality of coconut under coastal ecosystem. *Journal of Plantation Crops*, 2008, 36 (3): 249-253.
- 7) Dhar, S.A., Sakib, T.U. & Hilary, L.N. (2020). Effects Of Pyrolysis Temperature On Production And Physicochemical Characterization Of Biochar Derived From Coconut Fiber Biomass Through Slow Pyrolysis Process. *Biomass Conv. Bioref.* <https://doi.org/10.1007/S13399-020-01116-Y>.
- 8) Gopal, M., Gupta, A., Shahul Hameed, K., Sathyaseelan, N., Khadeejath Rajeela. T. H and Thomas., G. V. (2020). Biochars Produced From Coconut Palm Biomass Residues Can Aid Regenerative Agriculture By Improving Soil Properties And Plant Yield In Humid Tropics. *Biochar* 2, 211–226. <https://doi.org/10.1007/s42773-020-00043-5>.
- 9) Herviyanti. H., Maulana. A., Prima. S., Aprisal. A., Crisna. S. D, and Lita. A. L. (2020). Effect Of Biochar From Young Coconut Waste To Improve Chemical Properties Of Ultisols And Growth Coffee [*Coffea Arabica* L.] Plant Seeds. *International Conference Of Bio-Based Economy And Agricultural Utilization 2019. IOP Conf. Series: Earth And Environmental Science* 497 (2020) 012038. [Doi:10.1088/1755-1315/497/1/012038](https://doi.org/10.1088/1755-1315/497/1/012038) 1.
- 10) Khairol. I. and Mohammad. A. H. (2019). Utilization of coconut waste to enhance the growth and vigour of coconut cultivation on sandy soils. *Proceeding of Soil Science Conference Of Malaysia 2019*, 16-18 April 2019, Hotel Equatorial, Melaka, Malaysia. pp 163-169.
- 11) Khan, H.H. 1993. Fertilizer management in coconut In: Tandon, H.L.S. (Ed) *Fertilizer management in commercial crops*. Fertilizer Development and Consultation Organization, New Delhi, India. pp.176.
- 12) Khan, H.H. Sankaranarayanan, M.P. and Narayanan, K.B. 1978. Characteristics of Coconut Soils of India. 1. Morphology, Some physico – chemical, Characteristics and Taxonomy. *Proceedings of PLACROSYM I*: 54-79. ISPC, Kasargod, India.

- 13) Khandaker, Mohammad & Jahan, Md & Muslian, Isa. (2014). Effects of Soil Amendments on BRIS Soil Health, Crop Physiology and Production. *International Journal of Research and Innovations in Earth Sci.* 1. 6-9.
- 14) Maheswarappa. H.P, & Thomas, George & Gupta, Alka & Ravi, Bhat & Palaniswami, C. (2014). Productivity and nutrient status of coconut (*Cocos nucifera*) as influenced by integrated nutrient management with vermicomposted coconut leaves. *Indian Journal of Agronomy.* 59. 455-459.
- 15) Maheswarappa. H.P, Thomas George, Ravi Bhat, Palaniswami C. & Jayasekhar, S. (2011). Impact of inorganic fertilizer substitutions by vermicomposted coconut leaves on productivity and economics of coconut. 30-34.
- 16) Marimuthu. R. & C. Natarajan. (2005). Sand Curing Is Essential For Obtaining More Recovery Of Quality Seedlings In Coconut. *Indian Coconut J.*, 35(12): 325-340.
- 17) Nampoothiri, K .U. K. 2001. Organic Farming-Its relevance to plantation crops. *J.Plantn. Crops* 29(1): 1-9.
- 18) Parwaiz, A, B. Inayatullah, R, And Ubedullah, A, T. (2014). Effect Of Integrated Nutrient Management On Nut Production Of Coconut (*Cocos Nucifera L.*) And Soil Environment. A Review. Baloch Et Al., 2014. *Sci. Tech. and Dev.*, 33 (1): 14-21.
- 19) Ranaweera, S.R.M. & Nanayakkara, Chandrika & Tennakoon, N.A. (2012). Comparison Of The Effects Of Organic Fertilizers With Inorganic Fertilizers On The Growth Of Eight Months Old Coconut Seedlings And The Nutrient Availability And Soil Microbial Activity Of Soils. *Proc. of Int. Forestry and Env. Symposium.*
- 20) Sainath. N, Usha. P., Manorama. T. And Biju. J. (2021). Tender Coconut Husk Derived Biochar Impact On Soil Properties, Yield And Fruit Quality Of Banana. *Journal Of The Indian Society Of Soil Science*, Vol. 69, No. 3, pp 334-338 (2021) DOI: 10.5958/0974-0228.2021.00050.5.
- 21) Senjaliya, Hitesh & Vala, Gambhirsinh & Mangroliya, G.S. (2015). Nutrient Management Through Organic And Inorganic Manures In Coconut (*Cocos Nucifera L.*) Garden. *An Asian Journal Of Soil Science.* 10. 59-62. 10.15740/HAS/AJSS/10.1/59-62. Edward. J. P., 2009. "Soil Science And Management. 5th Ed. United States: Delmar Cengage Learning," P. 40-250.
- 22) Shinde, V., Sumitha, S., & Maheswarappa, H. (2021). Soil fertility properties, leaf nutrient status and yield of coconut and intercrops as influenced and coconut based cropping system in coastal plain of western India. *Bangladesh Journal of Botany*, 50(4), 1067–1075. <https://doi.org/10.3329/bjb.v50i4.57074>.
- 23) Srinivasa Reddy, D.V. and Upadhyay, A.K. 2002. Impact of integrated nutrient management on the mineral nutrition and yield of WCT coconut in littoral sandy soil at Kasaragod. pp. 274-251.
- 24) Subramanian, P et al. 2005. Glyricidia (*Gliricidia sepium*) as green manure in improving soil fertility and productivity of coconut under coastal littoral sandy soil. *J.Plantn. Crops* 33 (3): 185-189.
- 25) Syed, Manzar-ul-Alam & Shah, Syed & Ali, Sikander & Iqbal, Muhammad. (2005). Yield and phosphorus-uptake by crops as influenced by chemical fertilizer and integrated use of industrial by-products. *Songklanakarin Journal of Science and Technology.* 27.

- 26) Tandon, H.L.S. 1990. In: Proceedings of the International Symposium on Natural Resources Management for a Sustainable Agriculture (R.P.Singh, Ed.) 16th -10th February, 1990, New Delhi, pp 203-222.
- 27) Thomas, G.V., Prabhu, S.R., Subramaniam, P., Iyer, R. (1998): Organic Farming Technologies in Coconut. ATIC series Publication No. 4. Central Plantation Crop Research Institute, Kasaragod, Kerala.
- 28) Upadhyay, A.K., Maheswarappa, H.P., Palaniswami, C., Ravi Bhat, Subramanian, P. and George V. Thomas. 2009. Impact of composted coir pith on the nutrition and productivity of coconut. Indian Coconut J. 51(9): 2-5.